1) The punter on a football team tries to kick a football so that it stays in the air for a long "hang time". If the ball is kicked with an initial velocity of 25.0 m/s at an angle 60.0° above the ground, what is the hang time?

2) Michael Jordan, formerly of the Chicago Bulls basketball team had some fanatic fans. They claimed that he was able to jump and remain in the air for a full two seconds from launch to landing. Evaluate this claim by calculating the maximum height that such a jump would attain. For comparison, Jordan’s maximum jump height has been estimated at about one meter.

3) A criminal is escaping across a roof top and runs off the roof horizontally at a speed of 5.3 m/s, hoping to land on the roof of an adjacent building. Air resistance is negligible. The horizontal distance between the two buildings is D, and the roof of the adjacent building is 2.0m below the jumping-off point. Find the maximum value of D.

4) A rocket is fired at a speed of 75.0 m/s from ground level, at an angle of 60.0° above the horizontal. The rocket is fired toward an 11.0 m high wall, which is located 27.0 m away. The rocket attains its launch speed in a negligibly short period of time, after which its engines shut down and the rocket coasts. By how much does the rocket clear the wall?

\[ v_{yo} = v_0 \sin \alpha = (25 \text{ m/s}) \sin 60° = 21.65 \text{ m/s} \]

\[ v_{yo} \quad \text{use } y \text{-eq. to find "hang time"} \]

\[ y = y_0 + v_{yo} t + \frac{1}{2} a t^2 \quad y_0 = 0, \ a = -9.8 \text{ m/s}^2 \]

When ball reaches ground (end of hang time, \( t \)):

\[ 0 = 0 + (v_{yo} t) - \frac{1}{2} g t^2 = [v_{yo} - \frac{1}{2} g t] t = 0 \]

\[ \Rightarrow \text{ either } t = 0 \text{ or } t = \frac{2v_{yo}}{g} \text{ kick & landing} \]

\[ t = \frac{2(21.65 \text{ m/s})}{9.8 \text{ m/s}^2} \approx 4.425 \]

2) If he could hang in the air for two seconds, we can use the result from problem 1 to find his initial velocity, i.e., \( v_{yo} - \frac{1}{2} g t = 0 \) or

\[ v_{yo} - \frac{1}{2} g t = \frac{1}{2}(9.8 \text{ m/s}^2) 2 \text{ s} = 9.8 \text{ m/s} \]
we can use the initial velocity to find the max height which occurs at 1.5sec. (1/2 flight time)

\[ y = y_0 + v_{y0} t - \frac{1}{2} g t^2 \quad v_{y0} = 1.8 \text{ m/s}, \quad g = 9.8 \text{ m/s}^2 \]

\[ = 0 + (1.8 \text{ m/s})(1.5) - \frac{1}{2} 9.8 \text{ (m/s)^2} (1.5)^2 = \frac{1}{2} 9.8 \text{ m} = 4.9 \text{ m} \]

This tells us that to stay in the air for a full 2 seconds, MJ would have had to jump 4.9 m straight up. Note that a) this is about 5x his max jump height and b) this would put his feet way above the rim.

3) \( v_0 = 5.3 \text{ m/s} \)

1st calc. time to fall 2 meters.

if we start with \( y_0 = 0, \quad v_{y0} = 0 \) and measure \( y \) dir as down.

\[ y = \frac{1}{2} gt^2 \quad \text{means, \ dir is down} \]

\[ t^2 = \frac{2y}{g} = \frac{(2)(2m)}{9.8 \text{ m/s}^2} = \frac{4}{19.6} = 0.4085 \text{ sec} \]

\[ t = \sqrt{0.4085} = 0.6395 \text{ sec} \]

Now calc. distance that criminal can travel in the x-dir. in this amount of time

\[ x = x_0 + v_{0x} t \]

\[ x = (5.3 \text{ m/s})(0.6395) = 3.386 \text{ m} \quad \approx 3.4 \text{ m} \]
4) \[ V_{oy} = V_0 \cos \theta = (75) \cos 60^\circ = 37.5 \text{ m/s} \]

\[ V_{oy} = V_0 \sin \theta = 75 \sin (60) = 64.95 \text{ m/s} \]

1st use \( x \)-equation to calculate time required to reach the wall,

\[ x = x_0 + v_{ox}t \]
\[ x_0 = 0 \quad v_{ox} = 37.5 \text{ m/s} \]
\[ t = \frac{x}{v_{ox}} = \frac{27 \text{ m}}{37.5 \text{ m/s}} = 0.72 \text{ s} \]

Calculate \( y \)-height at this time.

\[ y = y_0 + v_{oy}t - \frac{1}{2} g t^2 \]
\[ y_0 = 0, \quad v_{oy} = 64.95 \text{ m/s} \]
\[ g = 9.8 \text{ m/s}^2 \]
\[ y = (64.95 \frac{\text{m}}{\text{s}})(0.725) - \frac{1}{2}(9.8 \frac{\text{m}}{\text{s}^2})(0.725)^2 \]
\[ = 44.2 \text{ m} \]

Since the wall is 11 m high, the rocket clears the wall by a distance

\[ d = 44.2 \text{ m} - 11 \text{ m} = 33.2 \text{ m} \]